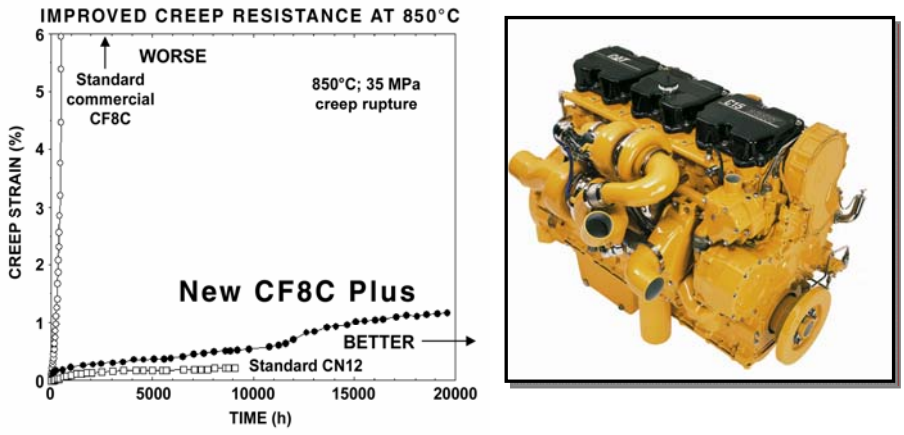
CF8C-Plus, New Cast Stainless Steel

Background

Advanced heavy truck diesel engines must have higher fuel efficiency and reduced emissions, without sacrificing durability and reliability. Diesel exhaust components such as manifolds and turbocharger housings must endure duty cycles that push maximum temperature beyond 750°C, and yet must also have long lifetimes.

To meet the performance demands of future advanced on-highway diesel engines, Caterpillar, Inc., and the Oak Ridge National Laboratory (ORNL) engaged in a collaborative research and development agreement to select or develop cost-effective materials alternatives to the silicon-molybdenum (SiMo) cast iron currently used for diesel exhaust components. Commercial cast stainless steels (like CF8C) had some of the desired properties, but lacked others. ORNL and Caterpillar developed a new modified cast stainless steel, CF8C-Plus, that had the best combination of high-temperature properties, was still castable, and had about the same cost as the standard CF8C steel. CF8C-Plus won a 2003 R&D 100 Award.



New CF8C-Plus cast stainless steel has outstanding creep strength at 650-850°C (left) and was developed for advanced exhaust components on heavy-duty diesel engines like the CAT C-15 14.6L on-highway engine (right).

The Technology

The new CF8C-Plus was developed in about 1 year, with first-heat/first-test success by employing a unique engineered microstructure method of alloy design. The standard CF8C steel is a niobium-stabilized iron-19 chromium-10 nickel (Fe-19Cr-10Ni)

Benefits

- CF8C-Plus steel can be commercially cast by various processes (static, centrifugal) to make large or small parts more easily than standard steels.
- CF8C-Plus is more heat-resistant that comparable wrought or C- or H-grade cast steel at 600-850ºC, and has creep strength comparable to many Ni-based superalloys at 700-800ºC.
- CF8C-Plus requires no additional heat treatments after casting.
- CF8C-Plus steel costs about same as the standard cast stainless steel grades.

cast steel that contains 20-25% delta-ferrite, which can be beneficial at lower temperatures, but rapidly transforms to sigma-phase at 600-650°C and above, which weakens and embrittles the steel.

The new CF8C-Plus has additions of manganese (Mn) and nitrogen (N), and careful adjustments to the alloy composition, to eliminate delta-ferrite and stabilize the austenite matrix phase, so that no sigma phase or other deleterious phases precipitate during prolonged thermal aging. The new alloying additions enhance the formation and stability of nano-scale dispersions of niobium-carbon (NbC), which provide creep strength at as high as 850ºC.

The CF8C-Plus stainless steel is stronger and yet has about the same high ductility as the standard steel. The combination of strength and ductility over a wide temperature range gives the new steel resistance to fatigue and thermal fatigue. The Mn addition give the CF8C-Plus more castability than the standard steel. Nano-scale NbC dispersions develop rapidly during high-temperature service, and properties performance is optimum in the as-cast condition, requiring no additional heat-treatments.

Commercialization

Commercialization of CF8C-Plus began with 500-pound air-melted, static cast heats produced by several commercial stainless steel foundries in 2003. It progressed to over 10,000 pounds of steel cast at the end of 2004, and component trials ranging from large castings for industrial gas turbines, to smaller castings appropriate for making diesel engine exhaust components. At the end of 2004, ORNL and Caterpillar had agreed on licensing details and strategies and several foundries had preliminary licenses for testing. The number of end-users interested in various applications is growing.

The development won a 2003 R&D 100 Award.

FreedomCAR & Fuel Partnership

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